SWIMMING BEHAVIOR OF INDIVIDUAL ZOOPLANKTERS DURING NIGHT-TIME FORAGING

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Award #N00014-96-1-0259

LONG-TERM GOALS

The long-term goal of this research is to learn in what ways and to what extent the individual behavior of zooplankters can affect overall zooplankton population distributions.

OBJECTIVES

The objectives of this research are two-fold: 1) to learn about euphausiid foraging strategies by observing the swimming behavior of large numbers of undisturbed individuals in the photic zone at different times of night, and 2) to learn how euphausiids partition energy between the vertical and horizontal components of motion at different times of night, particularly during vertical migration.

APPROACH

McGehee and Jaffe (1996) measured the three-dimensional tracks of over 300 individual plankters from a one minute long sequence of 3-D images collected with the three-dimensional acoustical imaging system FishTV (FTV) off the coast of California in March, 1993. The data were exciting because they showed evidence of swimming behavior related to area-restricted searching, an optimum foraging behavior for animals in a patchy food environment. However, the tracks were measured by hand, a laborious task indeed. In July 1994 Genin and Jaffe collected a much larger FTV data set in the Red Sea. Part of

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Swimming Behavior of Individual Zooplankters During Night-time Foraging	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Tracor Applied Sciences,4669 Murphy Canyon Road,San Diego,CA,92123**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

the data were collected during a three night moored deployment of the instrument at a depth of 27 m in the Gulf of Aqaba, approximately 1.2 km from shore, in water 280 m deep. The transducer had a large vane attached, intended to keep it aimed up-current, so that ensonified animals would be undisturbed by the hardware. The volume of water ensonified was approximately 5 m^3. The measurements were supplemented by simultaneous flow measurements using an S4 current meter. Two BONGO net tows made during the experiment indicated that euphausiids (*Euphausia diamedae, E. sanzoi*, *Stylocheiron abbreviatum*, and *S. affine*) were well represented in the fauna (10's to 100's per m^3).

The research performed under the present grant examines data from from the moored deployment. Our approach has been to develop a method for automatically tracking the animals in this data set and to examine the swimming trajectories thus determined at various times of night, with the goal of learning more about zooplankton night-time foraging, vertical migration behavior, and the partitioning of energy between horizontal and vertical components at different times of night..

WORK COMPLETED

In FY96 we developed a robust algorithm for tracking acoustic targets in the FTV 3-D image sequences. We have also developed a method for removing the component of animal movement due to gross water movement, leaving trajectories that we believe are due primarily to swimming behavior. In FY97 we used these methods to track several hundred thousand targets, and to compare their behavior at various times of night.

RESULTS

The three-dimensional swimming trajectories of several hundred thousand individual zooplankters were measured using the automatic tracking algorithm developed under this grant. Over 14,000 of the targets remained in the field-of-view for over 5 seconds (with the longest lasting over 97 seconds), and the trajectories of these targets were used in subsequent analysis. The tracks of the targets with target strengths below -75 dB re 1 micropascal were highly correlated with the horizontal flow measured simultaneously by an S4 current meter. These targets also exhibited strong vertical motions, apparently due to internal waves. In order to judge the swimming speeds of the animals themselves, the estimated mean flow was subtracted from each trajectory. These swimming speeds were generally much lower than the mean flow. Statistical analysis of the “flow-removed” tracks indicated that the variance in the vertical direction was much greater than the variance in the horizontal throughout the night. However the variance became more isotropic as dawn approached. A hop-and-sink foraging behavior that has previously been suggested for many forms of crustacean zooplankton is one possible explanation for the high night-time variance in the vertical direction.

IMPACT

Investigations regarding the role the individual plankter plays in determining population-wide distributions have been hampered in the past by lack of undisturbed three-

dimensional measurements of what the animals were doing. We now have over 14,000 trajectories of greater than five seconds length, which may be used to shed light on some of these questions.

RELATED PROJECTS

The data used in this project were originally collected by Genin and Jaffe under a grant from the U.S - Israel Binational Science Foundation. The research done under that grant has benefited from the automated tracking methods developed here. Two other projects have also benefited from the methods developed here: an ONR project by Jaffe and Franks entitled "Acoustic-Optic Integration and Visualization of 3-D Oceanic Measurement", and an NSF project by Ohman and Jaffe entitled "Combined Acoustic and Optical Imaging of Crustacean Macrozooplankton".

REFERENCES

McGehee, D and Jaffe, J. S., 1996. Three-dimensional swimming behavior of individual zooplankters: observations using the acoustical imaging system FishTV, *ICES J. Mar. Sci.,* **53**: 363-369.